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A device for the central controlling and/or monitoring of infusion pumps

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ABSTRACT

Device for the central controlling and/or monitoring of infusion pumps

The invention relates to a device for the central controlling and/or monitoring of infusion pumps (101A-101C,102A-102F), comprising an attachment and support unit (103) adapted for releasable arrangement thereon of a plurality of infusion pumps, to be controlled and/or monitored with regard to their functions, or having such pumps releasably arranged thereon, and a central control and/or monitor unit (110) adapted to have the infusion pumps connected thereto, the attachment and support unit (103) at predefined positions for support of the infusion pumps being provided with a respective interface to allow data communication for the connection of the respective infusion pump, and the central control and/or monitor unit (110) comprising a display device for visual representation of the condition of all of the infusion pumps connected thereto, with the topology of the visual representation of the infusion pumps on the display device corresponding to the topology of the arrangement of said infusion pumps on the attachment and support unit (103).

(Fig. 1)

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A device for the central controlling and/or monitoring of infusion pumps

The instant invention relates to medical systems and particularly to systems of infusion pumps used to administer medicants to critically ill patients.

In hospitals and other medical institutes, the administration of medicants, vitamins, nutrients and the like to critically ill patients is commonly performed through infusion pumps by the intravenous route, i.e. directly into the blood of the patient. Infusion pumps are commercially available substantially in two types. According to the first type, a syringe pump is arranged to advance a syringe plunger at a controlled advance speed to thus perform the intravenous administration of the contents of the syringe. According to the second type, pumps exists by which an infusion fluid arranged at an elevated level in an infusion bottle or an infusion bag is administered by a pump at a controlled supply rate. In the description hereunder, the term "infusion

pump" is to be understood as referring to both types of pumps.

In modern hospital environments, it has become an ever more customary practice to administer medicants not manually by means of a syringe anymore but, instead, to prepare predictable doses of medicants in a manner suitable for infusion pumps and to use such pumps to administer the medicants to the patient. Administration is often set to be performed at a constant supply rate but can also be performed discontinuously or according to a supply profile with variable supply rate. This frequent routinized application of infusion pumps results in a situation where, in a modern intensive care ward, an intensive care set has about a dozen infusion pumps connected thereto. In intensive care of critically ill patients, e.g. in the therapy for patient with heart diseases, it is not infrequently the case that a number of as much as 20 infusion pumps is exceeded.

In the previous state of the art, all of these pumps together with the other medical devices attached to the intensive care bed have amounted to a conglomeration of individual apparatuses, which along with numerous other factors considerably affects the ergonomics and the operability of intensive care workplaces. This is clearly described in "medizintechnik" 1/96 pp. 7-11, and for various reasons, a demand has been expressed for standardization and systematization. Further, in the same article, the fluid system of the company B. Braun Melsungen AG is mentioned as a partial solution for the handling of

infusion pumps. In this fluid system, the problematics with regard to workplace ergonomics and clear layout are addressed by providing a plug-in system for the individual infusion pumps in a holding plate, and a clearly surveyed display, shown in a display unit, of the operating parameters of each individual infusion pump together with further parameters of the patient. To lend flexibility to the system, individual infusion pumps can be added to and removed from the respectively dedicated plug-in sites, with the energy and data connections established automatically.

A possibility for the central input of parameters related to infusion pumps is described in U.S.-Patent 4,756,706. The inputting of these parameters is performed on a central unit which, in a stack-like arrangement, is mechanically and electrically connected to the infusion pumps and exchanges data with the latter. A massive disadvantage of this system is caused by the one-dimensionality of the arrangement because the mechanical and electrical connections from the central unit to the first infusion pump and then onward to the respective next infusion pump are established by stacking the pumps on top of each other. Out of practical considerations regarding the accessibility of each individual infusion pump and of the central unit, this stacked arrangement appears suitable only up to a number of about ten infusion pumps. In practical handling, the stacked arrangement causes the further disadvantage that the removal of an infusion pump arranged in the middle of the stack requires a partial disassembling

of the stack and a subsequent renewed assembling. In practical use, this presents a considerable disadvantage since, as detailed further hereunder, such a system of infusion pumps as used in a customary hospital environment is a dynamic system. A third considerable disadvantage of the described embodiment resides in that this system represents an island solution which does not allow any means for establishing data communications with devices not belonging to the system. Further, this system necessitates the use of special infusion pumps suitable for stacking. The use of existing pumps will normally not be possible.

In the past, a number of approaches has been proposed for providing the individual infusion pump with means for data communication and for utilizing said means in a suitable manner. An illustrative example is given in U.S.-Patent 5,376,070, related to a communications controller for data communication with an individual infusion pump adapted to have said controller detachably connected thereto. Thus, all of the individual infusion pumps can be programmed successively and will then operate individually after detaching the connection to the communications controller. This system does not allow for a truly centralized controlling and monitoring but merely offers a more convenient way of programming each infusion pump as compared to a programming performed on the pump itself.

A further aspect in this regard is described in U.S.-Patent 5,681,285 related to an infusion pump

provided with an electronic memory, wherein said memory can be loaded with a list of medicants and the user can select a medicant along with its appertaining parameter from this medicant list. Since, in this embodiment, the actual handling process is now as before performed on the infusion pump itself and since a connection to the externally compiled medicant list is established only in relatively large time intervals, said centralizing aspect is largely lacking.

Further efforts were untertaken in diverse embodiments by which medicants contained in a syringe or an infusion bottle were made machine-readable. This was frequently performed by printed bar codes adapted to be detected by means connected to the infusion pump or directly integrated thereinto. Examples thereof are given in the U.S.-Patents 4,978,335 and 5,317,506. Moreover, particularly in the more recent past, examples of infusion pumps can be found which are provided - in addition to the means required for their actual function - with functions for increasing their handling convenience by implementing further functions. One of these examples is U.S.-Patent 5,609,575, related to a computer for the calculation of infusion rates to be calculated according to inputs performed by the user.

To appreciate the advantage of a central infusion pump monitor, it is to be considered that the present complex infusion pumps can comprise as many as 19 individual keys for actuating the numerous functions. Normally, some of these keys have multiple

functions assigned thereto. Assuming a number of merely 10 infusion pumps on an intensive care bed, a number of 190 individual keys will have to be provided for operating this system. Further, each infusion pump is provided with its own optical display device, its own optical and acoustic alarm system and its own interfaces with superordinate systems for hospital data acquisition and signalling. Further still, the user interface of an individual infusion pump presently hardly fulfills the modern requirements with respect to ergonomic criteria because the financial margin for the individual infusion pump is very narrow. Normally, therefore, use is made only of simple monochrome alphanumeric liquid displays or seven-digit light diode displays. Since, on the other hand, the possibility to implement ever more complex functions also into infusion pumps - as rendered possible by improvements in computing capacity - has revealed a distinct discrepancy between what is technically feasible and what is reasonably manageable, new approaches should be found in this regard. On a central infusion pump monitor, a comfortable, modern graphic user interface can be installed which will significantly improve and accelerate the communication with the system. Further, such a central infusion pump monitor makes it possible to avoid material and financial expenditure in the individual infusion pump in that those functional elements which are not positively assigned to the actual pump function are completely or partially arranged externally of the infusion pump, which ultimately - even in consideration of the expenditure for the central infusion pump moni-

tor - can result in a reduction of the costs for the overall system. Examples of functional elements that are not assigned to the actual pump function and can thus be wholly or partially removed to sites external of the infusion pump, are the input keys, the display device or the power pack with accumulator. Likewise under financial aspects, one must consider the recently established obligation to exactly lay account for each individual care service performed on an intensive care patient. Presently, the record of the medicants administered by infusion pumps is updated almost exclusively manually. By use of a central infusion pump monitor, the connecting of infusion pumps to a superordinate patient data management system or a hospital information system is considerably facilitated because only a sole interface exits for connection of a large number of infusion pumps. This results in the convenient possibility to automatically document the administration of medicants to an intensive care patient for medical and accounting purposes.

A further application for such a central control of infusion pumps lies in the field of anaesthesia. In this regard, efforts have been made for several years to replace gas anaesthesia, as of yet the usually practiced form of anaesthesia, by intravenous anaesthesia. Among the reasons herefore are the increasingly reduced limit values for the concentrations of anaesthesia gases allowable in operating-theater workplaces, the thus implicated prohibition to have pregnant persons work in the field of anaesthesia, and the comparatively small side effects of

intravenously administered narcotics. Further reasons for the use of the so-called all-intravenous anaesthesia reside in the financial aspects since, in place of a complex and expensive anaesthesia apparatus, there are needed only a relatively simple and inexpensive respiration device and several customary infusion pumps, and in environmental aspects since all the anaesthesia gases used are suspected to have damaging influences on the earth's ozone layer.

For such an all-intravenous anaesthesia, at least three infusion pumps are required which induce the actual anaesthesia, the analgesia, i.e. the deactivation of consciousness; the analgesia, i.e. the diminution of pain sensitivity; and the muscle relaxation, i.e. the easing of tension in the muscles. Since the workplace situation in anaesthesia is presently determined substantially by two medical devices, the patient monitor for surveying the vital parameters ECG, blood pressure, oxygen saturation etc., and the anaesthesia apparatus for actual anaesthesia and respiration, so that the anaesthetist will communicate with superordinate systems instead of subsystems, it is desirable to transfer this principle of operation to all-intravenous anaesthesia. The input and output device for all of the infusion pumps installed on the anaesthesia workplace should be provided as a central infusion pump monitor. This would not only render the system more easily surveyable but would also facilitate the documentation which in anaesthesia is prescribed by law

and which presently in many cases is still performed manually.

With regard to the anaesthesia workplace, also U.S.-Patent 4,741,732 is of importance. Said patent describes an approach for maintaining a specific arterial plasma level, set by the user, of a medicant, e.g. a narcotic, which is administered by an infusion pump. The approach is based on previous serial examinations of a number of probands sufficiently large for statistic evaluation, subsequent generation of a model of the physiological processes, followed by use of the model on any desired patients while inputting parameters, e.g. the patient's body weight. It is described that all of the functions are set directly on the infusion pump, with a resultant complexity of the pump. Further, when using more than one medicant whose supply rate is controlled according to such a model, the parameters, e.g. the body weight of the patient, must be inputted on each individual infusion pump. Also against this background, a central infusion pump monitor would offer advantages.

On the basis of the above outlined state of the art, it is the object of the invention to provide a device for the central controlling and/or monitoring of infusion pumps which allows for a central controlling/monitoring of a plurality of infusion pumps, is produced in a simple and inexpensive manner, offers sufficient flexibility with respect to the number and arrangement of the infusion pumps and provides for high reliability in handling.

The present invention avoids the essential disadvantages of systems of infusion pumps according to the present state of the art, and a number of advantages are obtained for the use of such a system. The present invention comprises a central infusion pump monitor for controlling and monitoring two or more infusion pumps. The central infusion pump monitor includes one or a plurality of microprocessors with associated program and data memories, as well as one or a plurality of display and input units. Further, one or a plurality of data connections are provided between the central infusion pump monitor and the infusion pumps connected thereto. The central infusion pump monitor can include a power pack and a battery for its own power supply and for the power supply of all the connected infusion pumps. The central infusion pump monitor is arranged to output control instructions to all of the connected infusion pumps and to receive response data from these. The individual infusion pumps are at all times releasably attached to a support which also comprises the means for electrical connection between the infusion pumps and the central infusion pump monitor. The central infusion pump monitor can be placed largely at any desired position and is not confined to a specific position on this support; instead, it can be mounted separately from the support, e.g. on the patient's bed. The complete system is portable and thus can completely or partially accompany the patient when the patient has to moved to a different site. The central infusion pump monitor comprises means for computing the infusion rate to be supplied from each of the connected infusion pumps. For this

computation, use can be made of patient- or medicant-related parameters inputted by the user and of algorithms permanently stored in the memory of the central infusion pump monitor.

What is essential is the visual and preferably graphic representation, displayed in the display units, of the topology of the connected arrangement of infusion pumps, the possibility for the inputting of control instructions and control parameters on the central infusion pump monitor or - in restricted form - on each individual infusion pump, and the display of operating parameters and values of the connected infusion pumps in the display units of the central infusion pump monitor. A further feature is the connectibility of the central infusion pump monitor to documentation devices, e.g. a hospital information system, to printout devices, which may also be integrated into the central infusion pump monitor, and to signalling devices, e.g. a nurse call system. Further, a possibility exists for the connection of additional devices which, for instance, perform a measurement on the body fluid elimination, thus allowing for a balancing of the patient's intake and output of fluids. Further possibilities for connection comprise all of the devices known from data processing technology which, merely by way of example, include a mass memory, a keyboard, a mouse, a bar code reader and printer, a remote control and devices for data remote transfer. All of these devices can be integrated into the central infusion pump monitor as well as be connected externally thereof.

According to the idea of the invention, it is not relevant whether the central infusion pump monitor is an independent device or whether its function is integrated into a different device, e.g. a patient monitor for monitoring the vital parameters, a respiration device or a data processing device preferably serving for other purposes. Further, the central infusion pump monitor can be arranged within a sole housing or have its functional units distributed among a plurality of housings.

The invention will now be explained in greater detail with reference to the embodiments shown in the drawing.

Fig. 1 is a view of a exemplary arrangement of a system of infusion pumps;

Fig. 2 is a schematic view of an exemplary system of infusion pumps with a central infusion pump monitor and connections to peripheral devices;

Fig. 3 is an exemplary block diagram of a central infusion pump monitor according to the present invention;

Fig. 4 is a view of an example of the input menu for the setting of parameters for an infusion pump;

Fig. 5 is a view of an exemplary visual display for an infusion pump within the system of infusion pumps; and

Fig. 6 is a view of an exemplary visual display for the system of infusion pumps, composed of a plurality of visual displays according to Fig. 5.

An exemplary arrangement of a system of infusion pumps 101A-101C, 102A-102F with fluid reservoirs 105A-105C and infusion lines 104 is illustrated in Fig. 1. Arrangements of this type are already in practical use in hospital environments and can be varied depending on the respective medical requirement. In case of critically ill intensive care patients, for instance, the number of syringe pumps 102A-102F could be increased or a second stand 103 with infusion pumps could be arranged next to the first one. It will be obvious that the number of possible variations of the instant arrangement is practically unlimited and is restricted substantially only by the constructional configuration of the mechanical support for the infusion pumps and by the number of infusion pumps.

According to an essential aspect of the present invention, the topology of the system of infusion pumps, i.e. the spatial arrangement of the individual infusion pumps within the system, is not relevant. It is merely required that the topology of the system is known to the central infusion pump monitor or to the central control and/or monitor unit 110.

This can be accomplished either by automatic recognition of the topology or by manual input of the topology or by a combination of both of said options. Since, for an intensive care patient, the medical necessities will change over time during his stay in the intensive care ward, such a system of infusion pumps is to be understood as a dynamic system wherein system components can be added or removed during continued operation and wherein operating parameters, e.g. medicants to be administered, administered doses, the time schedule for administration and the like. For this reason, an automatic recognition of the system topology is preferable to a manual input thereof because of the reduced effort for operation and the reduced error potential. For the same reason, the adding and removal, respectively of a system component is preferably performed in such a manner that both the mechanical and the electric connections to each system component can be established or interrupted without any further user activity when the respective system component has been correctly locked on the support 103 or released therefrom.

Since the present invention is based on the use of infusion pumps, along with their support systems 103, which have already been introduced on the market, and does not involve the necessity for a development of new infusion pumps and support systems, the connection between each individual infusion pump 101A-101C, 102A-102F to the central infusion pump monitor 110 must be established in a suitable manner. According to one aspect of the present inven-

tion, the identifying of the system topography and thus of the spatial arrangement of each individual infusion pump within the system is carried out through wiring. As shown in Fig. 2, a data connection 220 exists between each individual infusion pump 101A-101C, 102A-102F and the central infusion pump monitor 110. Via this data connection 220, the individual infusion pump 101A-101C, 102A-102F receives control instructions from the central infusion pump monitor 110 and transmits state information to the central infusion pump monitor 110. Since, in the present embodiment, the central infusion pump monitor 110 and the individual infusion pumps 101A-101C, 102A-102F are linked by a star-connected wiring, it is easily evident that the topography of the system can be detected by interrogation of each individual position by the central infusion pump monitor 110. The individual infusion pump 101A-101C, 102A-102F is merely required, in response to a specific instruction issued by the central infusion pump monitor 110, to transmit its status and operational data or to initiate such transmission on its own, which can be done continuously or at discrete points of time. Since, as described above, a normal hospital environment demands that the system be dynamically adaptable to medical requirements, the support system 103 inclusive of the wiring must be adapted for extension within set limits. This can be accomplished by individual elements arranged to mechanically support a plurality of infusion pumps 101 and/or 102 while at the same time safeguarding the correct wiring to each individual infusion pump 101 and/or 102 and to the respective next element and

from the respective preceding element. It is also conceivable that the topology of the system is provided to differ from the linear arrangement and is made two-dimensional, as shown by way of example in Fig. 2. The described star-connected arrangement of the individual infusion pumps 101A-101C, 102A-102F to the central infusion pump monitor 110 is just one possible embodiment: Further, it is possible to arrange this connection in accordance with the various network configurations sufficiently known from data processing technology, e.g. as an annular connection, a bus connection or combinations thereof. Of essence is only the clear identifiability of each individual infusion pump 101A-101C, 102A-102F within the system and the possibility to locate them within the topological arrangement. In the described star-connected arrangement, this is very simple and can be realized in a reliable manner; in a different network configuration, this may entail additional provisions with regard to the software, the hardware or in he constructional design of the system.

If the user, as explained hereunder with reference to Fig. 3, changes the setting of a parameter of one of the connected infusion pumps by operating an input unit 305, this setting will appear in a display unit 304 of the central infusion pump monitor 110. Upon confirmation of the correctness through the user, the two microprocessors 301 and 302 will independently from each other acquire and process this setting and transmit the same to the microprocessor 303. Microprocessor 303 performs a comparison between the data transmitted from the microprocessors

301 and 302 and, if these data coincide with each other, outputs the setting to the respective infusion pump via a data connection 220. To increase the reliability and the operational safety, the respective infusion pump responds by outputting, via a data connection 220, response data from which the correctness of data transmission can be derived. The respective infusion pump transmits these response data to the microprocessor 303, and the latter transmits the response data in identical form further onward to the microprocessors 301 and 302 which will independently from each other compare the transmitted data with the response data to thus examine the correctness of the data transmission. For time-dependent processes, the central infusion pump monitor 110 is provided with a real-time clock 308 which also serves a second safety feature against errors in the operating cycle of the microprocessors. Each of said microprocessors 301-303 comprises program memories 306,309,311 and data memories 307, 310,312 and, if required, additional peripheral units 317. According to the instant exemplary embodiment, the communication between the central infusion pump monitor 110 and the individual infusion pumps is performed via respective serial data connections 220 which establish the connection to the microprocessor 303 via a corresponding number of UARTs Universal Asynchronous Receiver and Transmitters 313. Additional devices 210,230 for connection to the central infusion pump monitor 110, e.g. for measurement of the patient's fluid elimination, are connected preferably via one or a plurality of similar data connections 221,222. As an electric speci-

fication, the norm RS485 for half-duplex operation is selected because of its high noise immunity. The above, however, is merely one possible embodiment of the data connections 220-222, further possibilities comprise all network types known from data processing technology, e.g. RS232, Ethernet, CAN, I2C, Firewire, USB etc. Further components of the central infusion pump monitor are a power pack 315 and a rechargeable battery 316 for power supply to the central infusion pump monitor 110. For data communication with external devices, e.g. a superordinate data processing device 202, a printout device 203, a patient monitor 204, a nurse call system 205 and further input/output units 206, use is made of specially adapted peripheral means 314 coupled to one or a plurality of the existing microprocessors 301-303 via one or a plurality of data connections. The power pack 315 and the battery 316 can also be arranged to supply power to all of the infusion pumps connected to the central infusion pump monitor 110, and to additional devices. In any case, they supply power to the central infusion pump monitor 110.

The separation into a plurality of microprocessors 301 and 302 is a common feature for safety-relevant applications but is not a precondition in the sense of the invention. Further embodiments can comprise all of the known methods for achieving a so-called first-error safety in the central infusion pump monitor. The first-error safety represents the common safety philosophy in medical products to the effect that any random first error must be prevented to cause any danger to the patient, the operating per-

son or third persons. Further, it is required that an occurred first error is detected within a time period where there is no likelihood of an occurrence of a second error which is independent of the first error. To achieve this first-error safety, the actual transmission of data from and to the infusion pumps has in the present embodiment been protected from transmission errors by use of safety measures commonly used in data processing technology. In the present embodiment, errors in the further processing of the user inputs into control instructions for individual infusion pumps are minimized by providing a hardware and software diversity between the microprocessors 301 and 302, i.e. the two microprocessors 301 and 302 are of different types and carry out different programs which obtain their results through different arithmetic approaches. Since specific parts of the central infusion pump monitor, e.g. the display units 304, can not at all or only with considerable effort be safely protected against first errors, it has been provided for that purpose that the user inputs are performed in two stages to thus obtain the same safety. In a first step, the user inputs his instructions through an input means 305. In the selected embodiment, there is provided a combined inputting via keys and a rotary switch. The input will then be presented in at least one display unit 304. In the selected embodiment, this is a menu-assisted graphic user surface on an active-matrix liquid crystal color display device, similar to the use surfaces sufficiently known from the field of data processing. After completion of all inputs within a menu, all of the safety-relevant inputs

will be displayed once more on other positions on the screen so that the user can perform a comparison between the instructions inputted by him and the instructions read by the central infusion pump monitor 110. Only after a positive confirmation of correctness by the user, the instructions will be processed and finally be transmitted to one of the infusion pumps. Fig. 4 shows an example of such an input menu 401.

After successful transmission of the instructions to the infusion pump, the latter, according to its respective design, can continue its operation in a more or less self-contained manner, even when detached from the central infusion pump monitor 110 by removal from the support. In infusion pumps for completely self-contained operation, a sequence of instructions is performed in the infusion pump which will initiate the same processes as if the infusion pump were connected to the central infusion pump monitor 110. In infusion pumps which are not designed for completely self-contained operation and are provided for a smaller range of functions, a removal of the infusion pump from the support 103 would cause the most recently set supply rate to be maintained or, in special cases such as, e.g., the profiles described further hereunder, the infusion pump removed from the support 103 would switch over into a safe condition, which is normally the condition of pump standstill.

According to a further aspect of the invention, all of the connected infusion pumps are displayed on at

least one display unit 304 of the central infusion pump monitor 110, preferably in graphic form. To eliminate the risk of wrong manipulation, the display will be carried out schematically by visually representing the topological arrangement of the real system of infusion pumps in the respective display unit 304. Thus, the assignment of each infusion pump to its visual representation on the central infusion pump monitor 110 can be easily surveyed by the operating staff. This is an important feature with regard to the system safety and the acceptance of such a system. The issuing of a instruction to a specific infusion pump will now be performed by selecting the desired infusion pump by means of an input unit 305. This selection is carried out through functions commonly provided for graphic user surfaces, e.g. by positioning a frame, changing the background color, inverting a screen area or stressing the selected object in a different manner. After a positive confirmation of the selection through the user, the user is given access to a menu 401, as shown by way of example in Fig. 4, which comprises all possible settings for a special infusion pump. This settings can relate to: name of medicant, concentration of medicant, desired dosage, desired supply profile, and so forth. In the preferred embodiment, the setting is performed by selecting a point on the menu by suitable input means 305, e.g. a rotary switch, arranged to cause a movement of the cursor on the screen, and by a subsequent confirmation of the selection through suitable input means 305, e.g. by pushing said rotary switch. A desired setting, e.g. the concentration, can now be selected by turning

the rotary switch until reaching the desired value, and subsequently pushing the rotary switch to thus conform the setting. Some components of the menu 401 can be arranged in a variable manner, as would be reasonable e.g. for the inputting of the parameters of a profile. The menu 401 shown in Fig. 4 can cover the whole display area or only a part of the display area of the respective display unit 304. In the exemplary embodiment, this menu occupies only a part of the display area. A second part shows all operating data of the selected infusion pump, e.g. in a display layout according to Fig. 5. A third part can show the visual representation of all the safety-relevant settings to allow for a repeated confirmation by the user. Further, by the graphic representation of the topological arrangement of the system of infusion pumps, the user will by just one look obtain a survey on the condition of all connected infusion pumps. This condition can include the current operating state "running"/"stopped", the current filling level of the fluid reservoir as e.g. the syringe, the current supply rate, the battery condition and the like. A special advantage of the central infusion pump monitor is offered by the centralization of the alarm output. By the described graphic representation of the topological system arrangement, an infusion pump which is causing an alarm can be quickly and reliably localized by being indicated in the display units in a visual manner clearly distinguished from that of the other infusion pumps. Further, the reason for the alarm and further information can be inserted into screen of the display unit. In connection with the triggering

of an alarm, a further advantage of the described central infusion pump monitor 110 becomes evident, notably the significant reduction of the effort for connection to a so-called nurse call system 205. These are signalling message systems commonly used in hospitals, which, in case of an alarm from a connected device, trigger an optical and/or acoustic signal at the site of the health-care staff. In patient monitors for the surveillance of the vital parameters, this technique, along with the central display of the vital parameters, has been established for a long time; in infusion pumps, a connection to a nurse call system 205 has of yet been mostly omitted due to the large number of individual devices per intensive-care bed. With the central infusion pump monitor 110, the complexity of the connections is reduced to a sole connection for all of the infusion pumps included in the system, finally resulting in a financial advantage.

A special advantage of the graphic user interface consists in the convenient option to set and visualize so-called profiles. A profile is the supply rate of an infusion pump following the function of time and possible further parameters. In the most simple case of a profile, the infusion pump will work at a supply rate that is constant over time. Further profiles can be provided with rising and falling ramps, be subjected to a limit as to time or volume, be arranged to follow a randomly desired arithmetic function as e.g. the exponential function, or be provided in with similar features. A further embodiment of the profile relates to the

bolus administration which is often required in medical practice and is performed in certain time intervals, e.g. three times per day, in specific quantities. On the central infusion pump monitor 110, the selection of such profiles and the setting of their parameters can be performed much more comfortably than would be possible on the individual infusion pump due to the lack of suitable means for visualization; in practice, up to now, this condition has had the effect that such profiles were generated almost exclusively by activities on the side of the health-care staff. The automatic generation of profiles and their transformation into control instructions for the individual infusion pump clearly alleviates the working burden on the health-care staff and results in a more exact dosage of the individual medicants. One possibility for a widening of the profiles is the so-called teach-in. In teach-in operation, the central infusion pump monitor stores all actions performed by the user, i.e. the user controls the infusion pumps in the conventional manner by hand and makes his decisions on the basis of his complex medical knowledge which for the most part cannot be rendered by formula and rules. After completion of the teach-in operation, the user can provide the thus stored sequence with a unique identification which can be referred to in the future to again reproduce this sequence of actions at all times without further user involvement. In the field of automatization technology, this teach-in principle has been used for a long time; in connection with all-intravenous anaesthesia, this approach promises to attain importance also on the medical

sector because the dosage of narcotics, as already common in conventional gas anaesthesia, is dependent on parameters, e.g. body weight of the patients, age, sex and medical experience. A further widening of the profiles can reside in pharmacokinetic models wherein the distribution of an administered medicant in the patient's body is simulated by suitable models. This models are medicant-specific and will be provided with further parameters, e.g. weight or age of patient. The objective value in this regard is a desired plasma level in the patient's blood, i.e. a desired concentration of this medicant. This desired concentration can be constant over time, if it is only intended to replace the amount of the medicant that the body will absorb per time unit, or the concentration can be variable over time. It is the purpose of the pharmacokinetic model to control the supply rate of the infusion pump by a control algorithm in such a manner that, in consideration of the input parameters, the actual concentration of this medicant in the blood is equal to the desired concentration. Such a pharmacokinetic model can be implemented in the infusion pump itself as well as in the central infusion pump monitor 110, while, for the above reason of user-friendliness, implementation in the central infusion pump monitor 110 is to be preferred.

A further aspect of the invention is directly related to the above profiles. According to this aspect, the medicant prescriptions, which previously have mostly been manually entered into the prescription sheet by the physician, and the medicant administra-

tions performed by the health-care staff in the course of the day, are automatized, at least regarding the medicants administered by infusion pumps. For this purpose, the central infusion pump monitor 110 is provided with at least one interface to at least one superordinate data processing device 202 into which the prescription plan is inputted instead of the prescription sheet which is filled by hand. Another possibility resides in the input of the prescription plan into a patient monitor 204, while the central infusion pump monitor can be provided with a data connection for this purpose. According to a third possibility, the prescription plan can be inputted into the central infusion pump monitor 110 itself. Regardless of which one of the described possibilities that has been selected for inputting the prescription plan, the prescription plan will enter the central infusion pump monitor 110 and is performed therein in the same manner in which a health-care worker would perform it manually, i.e. at the times defined by the physician in the prescription plan, pumps are automatically started or stopped or supply rates are changed, and the like. This represents a further step towards relieving the health-care staff from routine tasks, and will also reduce the risk for errors by decreasing the complexity of the process on one level.

The medicants used in an intensive care ward are normally taken from a specific stock of medicants which are applied on the patient depending on the medical requirement. With each hospital having its own stock of medicants, it appears reasonable, in-

stead of newly inputting these medicants at the time of each application, to have them registered in a medicant data bank and to select among them when required. Since, for a clear documentation, it is indispensable that the data for each medicant to be administered by the infusion pump are available to the central infusion pump monitor 110, the present invention provides that the central infusion pump monitor 110 is coupled to a medicant data bank. This medicant data bank can be arranged in the central infusion pump monitor 110 as well as in external devices, e.g. 202, as already described above in connection with the prescription plan. Normally, the medicant data bank is once generated according to the requirements of the respective hospital and is updated when required. The medicant data bank contains information for each medicant, e.g. name of medicant, allowable units of concentration, allowable range of supply rate, dosage parameters and the like. As illustrated in Fig. 4, the inputting by means of a screen menu is restricted to the selecting of the medicant name from the medicant data bank, the inputting of the concentration as well as of the supply parameters, e.g. selecting the profile. As accompanying information on the respective medicant, the medicant data bank can contain allowable profiles the respective medicant. Further, according to an important aspect of the invention, each medicant can have a specific color assigned thereto. This specific color will then be represented in the display image according to Fig. 5 by colored indications of all characteristics assigned to a medicant, e.g. name of medicant, concentration,

current supply rate, quantity still remaining in the fluid reservoir, future and past shape of profile. This possibility of a selective assignment of colors allows for a considerably easier survey of the system. Thus, for instance, all cardioactive medicants can have the color red assigned thereto, which up to now was often done by colored labels for attachment on the syringes. As further shown in Fig. 5, the screen display image 501 of each infusion pump is divided into different areas. A first area 502 is provided to display indications with regard to the current conditions of the pump, e.g. pump working /pump inactive, symbolized by an virtual rotating wheel; mains or battery operation, symbolized by the corresponding standard symbol; alarms, symbolized by a bell, and the like. A second area 503 shows the name of the medicant administered by the infusion pump, the concentration of the medicant and the quantity of fluid remaining in the syringe in relation to the full contents of the syringe. In case of an infusion pump supplying a fluid from a fluid reservoir arranged on a higher level, the already infused quantity is represented instead of the remaining quantity. A third area 504 shows the current supply rate of the infusion pumps, measured in physical units. A fourth area 505 shows the supply profile of the infusion pump. This profile is preferably shown as a graphic representation, with the time axis arranged horizontally and the supply rate represented vertically. The area left of center shows the past, and the area right of center shows the future. The area of the past is represented as a filled surface, and the area of the future is repre-

sented as a line corresponding to the selected supply rate. The center line represents the current point of time. For flexible adaptation to the conditions in a hospital environment, the scaling of the time axis, i.e. the space of time shown for the past and the present, is adjustable; thus, for instance, in intensive care wards, an adjustment can be made by a period of time of six hours in both directions while, for applications in operational theaters, shorter time periods of e.g. 30 minutes in both directions can be selected. In a fifth area 506, alarms and messages related to the respective infusion pump are displayed.

Further, the central infusion pump monitor offers possibilities for call and display of further menus, which, like the menu 401 of Fig. 4 described further above, are operated by means of an input unit 305. Such a menu can be e.g. a patient menu for input of all patient-related data. A further menu of this kind is a trend menu for an easily surveyable representation of the medicant administration as performed over time by each infusion pump connected to the system. A further menu of this kind is a general adjustment menu for the inputting of general data such as the date and the time of day as well as of further setting parameters for the internal functions of the central infusion pump monitor 110. These menus are not illustrated here because they are not principally different from corresponding menus as found e.g. in patient monitors according to the present state of the art.

For each connected infusion pump, there is provided a display device 502 as shown by way of example in Fig. 5. If a plurality of such display devices according to Fig. 5 are combined in a manner allowing the topology of the system of infusion pumps to be read from the display unit 304, a visual representation as in Fig. 6 is obtained. Shown here is an example of the screen display layout for the system of infusion pumps 101A-101C, 102A-102F from Fig. 1. The individual infusion pumps 101A-101C, 102A-102F are provided with respective display areas 602A-602C, 603A-603F assigned thereto. In addition to the fields for the individual infusion pumps, at least one display unit is provided with one or a plurality of display areas 601 containing general indications not assigned to a specific infusion pump, e.g. name, age and weight of patients, date and time of day and the like. The individual fields 602A-602C, 603A-603F for the individual infusion pumps can also be arranged to differ from the standard layout as circumstances may require. Thus, for instance, it can be seen in Fig. 6 that infusion pumps with infusion bag 101A-101C can be provided with a slightly different display image than syringe pumps 102A-102F. Further, it is possible to generate different representations for different types of infusion pumps. What is of essence is the quick and easy survey to be obtained on the system of infusion pumps by the graphic representation of the topological arrangement of the individual infusion pumps on at least one display unit of the central infusion pump monitor 110.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A device for the central controlling and/or monitoring of infusion pumps, comprising

a) an attachment and support unit adapted for releasable arrangement thereon of a plurality of infusion pumps, to be controlled and/or monitored with regard to their functions, or having such pumps releasably arranged thereon, and

b) a central control and/or monitor unit adapted to have said infusion pumps connected thereto,

w h e r e i n

c) said attachment and support unit at predefined positions for support of said infusion pumps is provided with a respective interface to allow data communication for the connection of the respective infusion pump, and

d) said central control and/or monitor unit comprises a display device for visual representation of the condition of all of said infusion pumps connected thereto, with the topology of the visual representation of said infusion pumps on said display device corresponding to the topology of the ar-

rangement of said infusion pumps on said attachment and support unit.

2. The device according to claim 1, wherein, in addition to said interfaces for data communication, an interface for energy supply of the respective infusion pump is provided at one or a plurality of said predefined positions for said infusion pumps.

3. The device according to claim 1, wherein said attachment and support unit has provided thereon a central energy supply unit connected to said interfaces for energy supply.

4. The device according to claim 1, wherein said infusion pumps and said central control and/or monitor unit are further provided with an autonomous emergency energy supply means which upon failure of said central energy supply unit will safeguard the reliable functioning of said infusion pumps.

5. The device according to claim 1, wherein said central control and/or monitor unit comprises a subunit provided on said attachment and support unit, and a superordinate unit connected thereto, wherein said subunit is arranged to independently control predetermined functions of said

infusion pumps and/or to control the communication between said infusion pumps and said superordinate unit.

6. The device according to claim 5, wherein said superordinate unit is arranged in a separate housing.

7. The device according to claim 5, wherein said control and/or monitor unit or said superordinate unit is releasably connected to said attachment and support unit and is arranged to be freely positioned.

8. The device according to claim 1, wherein the attachment of said infusion pumps to said attachment and support system is arranged in such a manner that a mechanical fastening can simultaneously establish a connection to the respective interface for data communication with said central control and/or monitor unit.

9. The device according to claim 1, wherein said interfaces for data communication and said infusion pumps are arranged in such a manner that, after detachment of an infusion pump from said attachment and support system, said infusion pump immediately detects said detachment and independently continues its operation in its

predetermined function or maintains the last held operative condition or enters a safe condition.

10. The device according to claim 1, wherein, in addition to said infusion pumps, one or a plurality of further modules for detecting physiological parameters of a patient can be arranged on said attachment and support unit and/or be connected to said central control and/or monitor unit.

11. The device according to claim 5, wherein the central control and/or monitor unit, preferably said subunit, is connectible to one or a plurality of other devices within the patient environment or to another largely non-transportable device within the medical institute to allow for data exchange.

12. The device according to claim 5, wherein the central control and/or monitor unit, preferably said superordinate unit, comprises input means for user input of parameters for control of said infusion pumps.

13. The device according to claim 1, wherein the system comprises means for the computation of infusion rates from the parameters inputted by

the user, said parameters preferably comprising the concentration of a physiologically active substance within the fluid and/or the body weight of the patient and/or a desired concentration of said physiologically active substance in the blood of a patient.

14. The device according to claim 10, wherein one or a plurality of physiological parameters measured by one or a plurality of suitable measuring devices or parameters derived from said measured physiological parameters will influence the result of the computation of the infusion rates.

15. The device according to claim 1, wherein said central control and/or monitor unit is provided to have a list of medicants and parameters related to said medicants inputted therein manually or from another device, and to store said parameters therein.

16. The device according to claim 15, wherein said list of medicants along with the parameters related to said medicants can be varied by manual input.

17. The device according to claim 1, wherein specific conditions of the individual infusion pumps,

particularly alarm, can be displayed by said central control and/or monitor unit.

DATED THIS 17 day of May 1999

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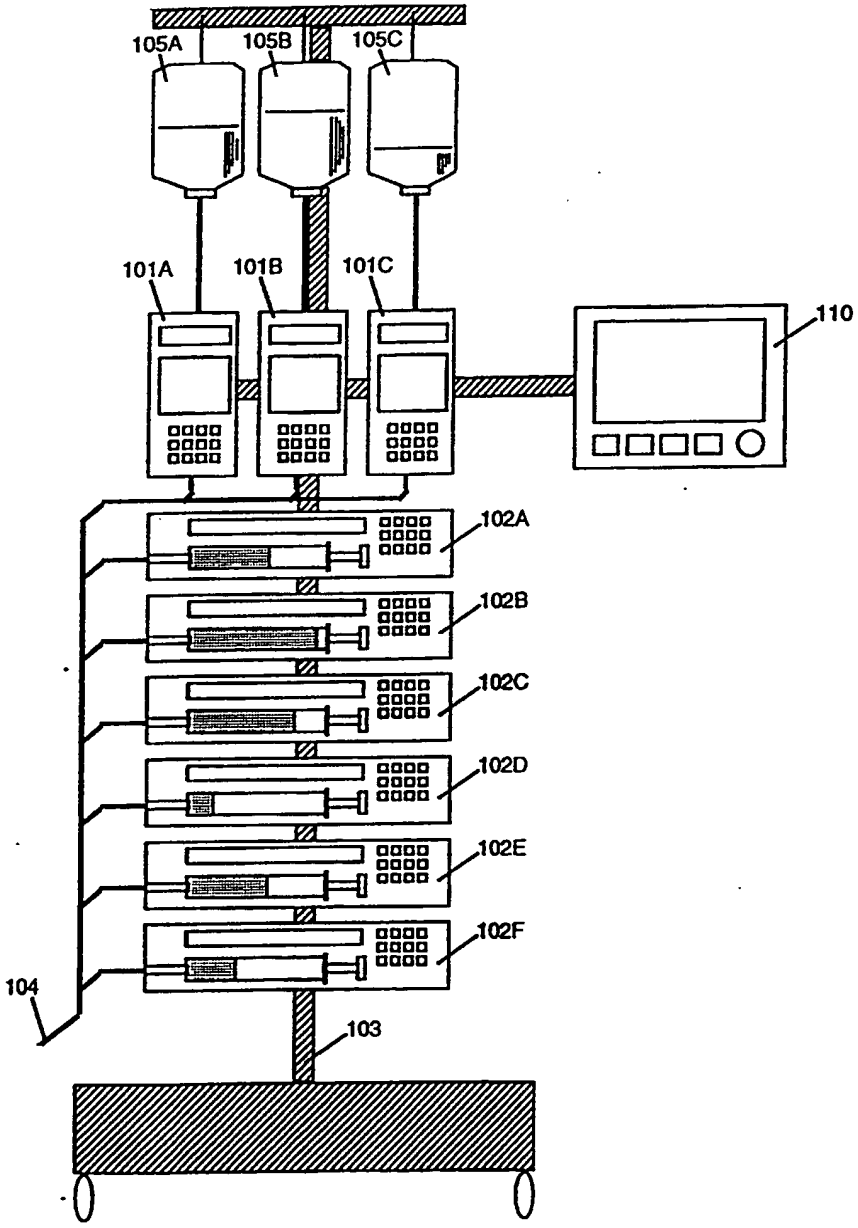
105A
105B
105C
101A
101B
101C
110
102A
102B
102C
102D
102E
102F
104
103

Fig. 1

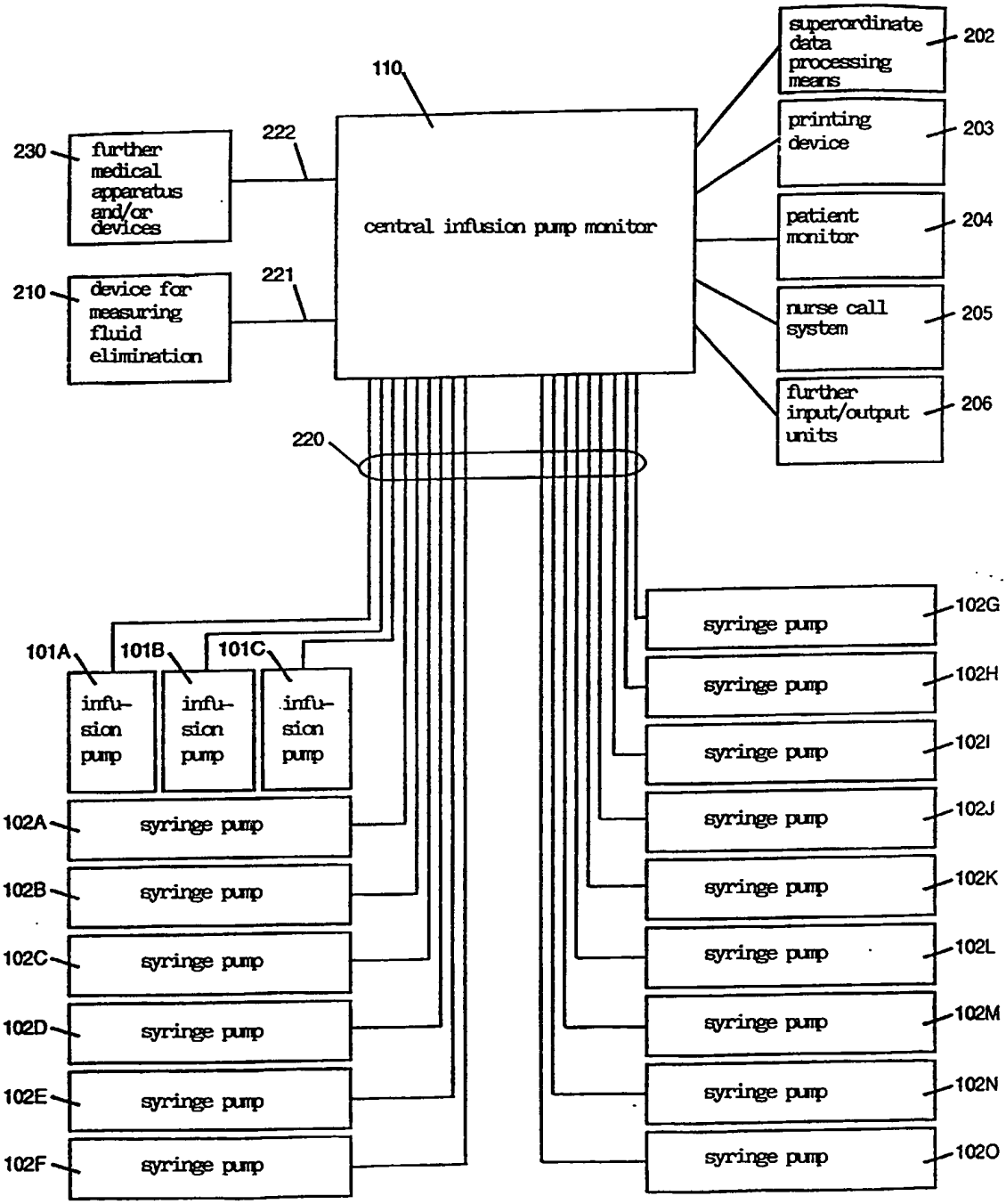
110
central infusion pump monitor
superordinate data processing means
202
printing device
203
patient monitor
204
nurse call system
205
further input/output units
206
222
230
further medical apparatus and/or devices
221
210
device for measuring fluid elimination
220
101A
101B
101C
infu-sion pump
infu-sion pump
infu-sion pump
102A
syringe pump
102B
syringe pump
102C
syringe pump
102D
syringe pump
102E
syringe pump
102F
syringe pump
102G
syringe pump
102H
syringe pump
102I
syringe pump
102J
syringe pump
102K
syringe pump
102L
syringe pump
102M
syringe pump
102N
syringe pump
102O
syringe pump

Fig. 2

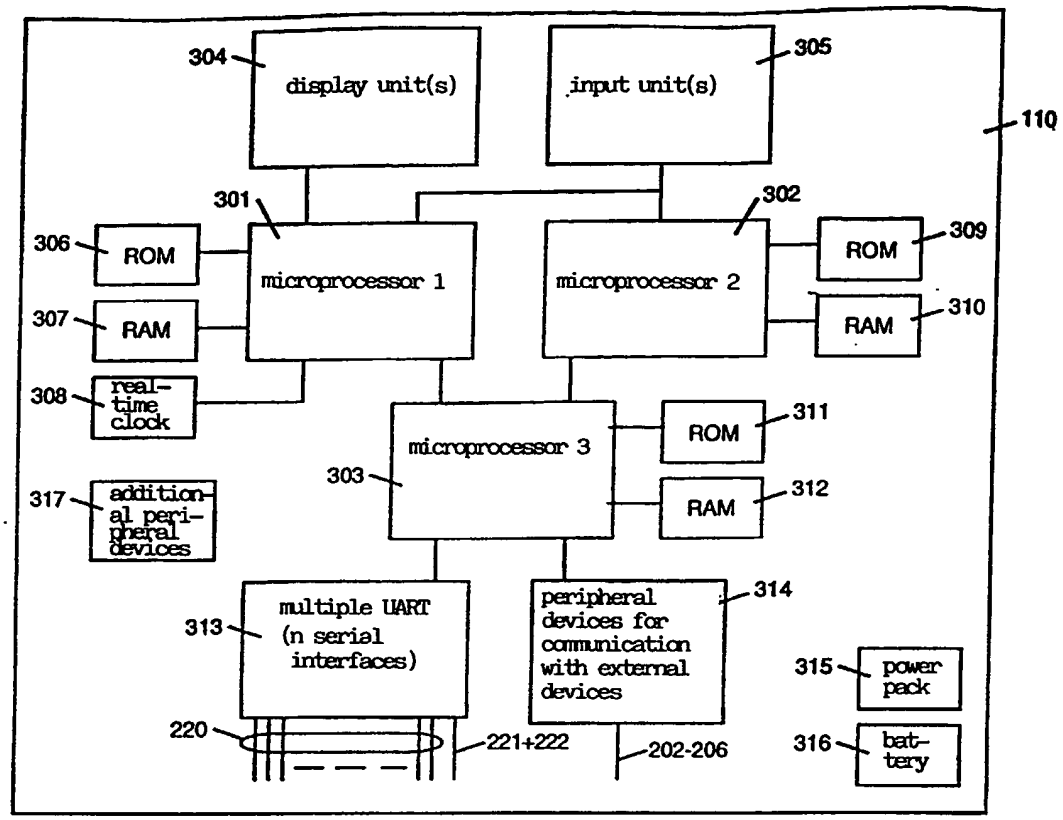
304
display unit(s)
305
input unit(s)
110
301
302
306
ROM
microprocessor 1
microprocessor 2
ROM
309
307
RAM
RAM
310
308
real-time clock
microprocessor 3
ROM
311
303
RAM
312
317
additional peripheral devices
multiple UART (n serial interfaces)
313
peripheral devices for communication with external devices
314
315
power pack
220
221+222
202-206
316
battery

Fig. 3

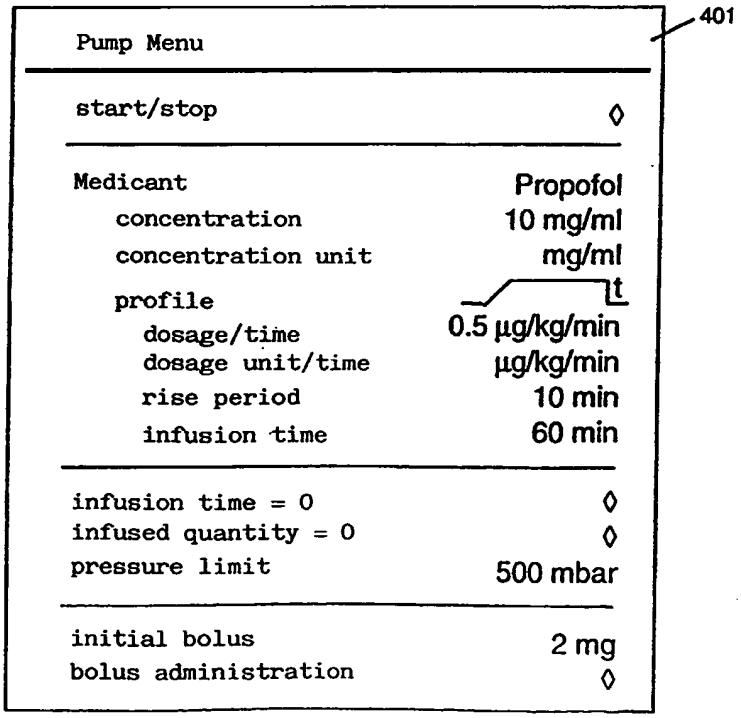
401
Pump Menu
start/stop
◊
Medicant
Propofol
concentration
10 mg/ml
concentration unit
mg/ml
profile
t
dosage/time
0.5 µg/kg/min
dosage unit/time
µg/kg/min
rise period
10 min
infusion time
60 min
infusion time = 0
◊
infused quantity = 0
◊
pressure limit
500 mbar
initial bolus
2 mg
bolus administration
◊

Fig. 4

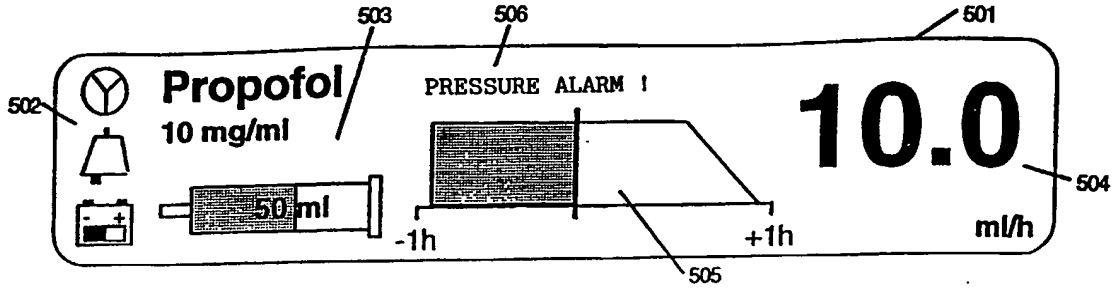
503
506
501
Propofol
10 mg/ml
PRESSURE ALARM !
502
10.0
50 ml
-1h
+1h
ml/h
504
505

Fig. 5

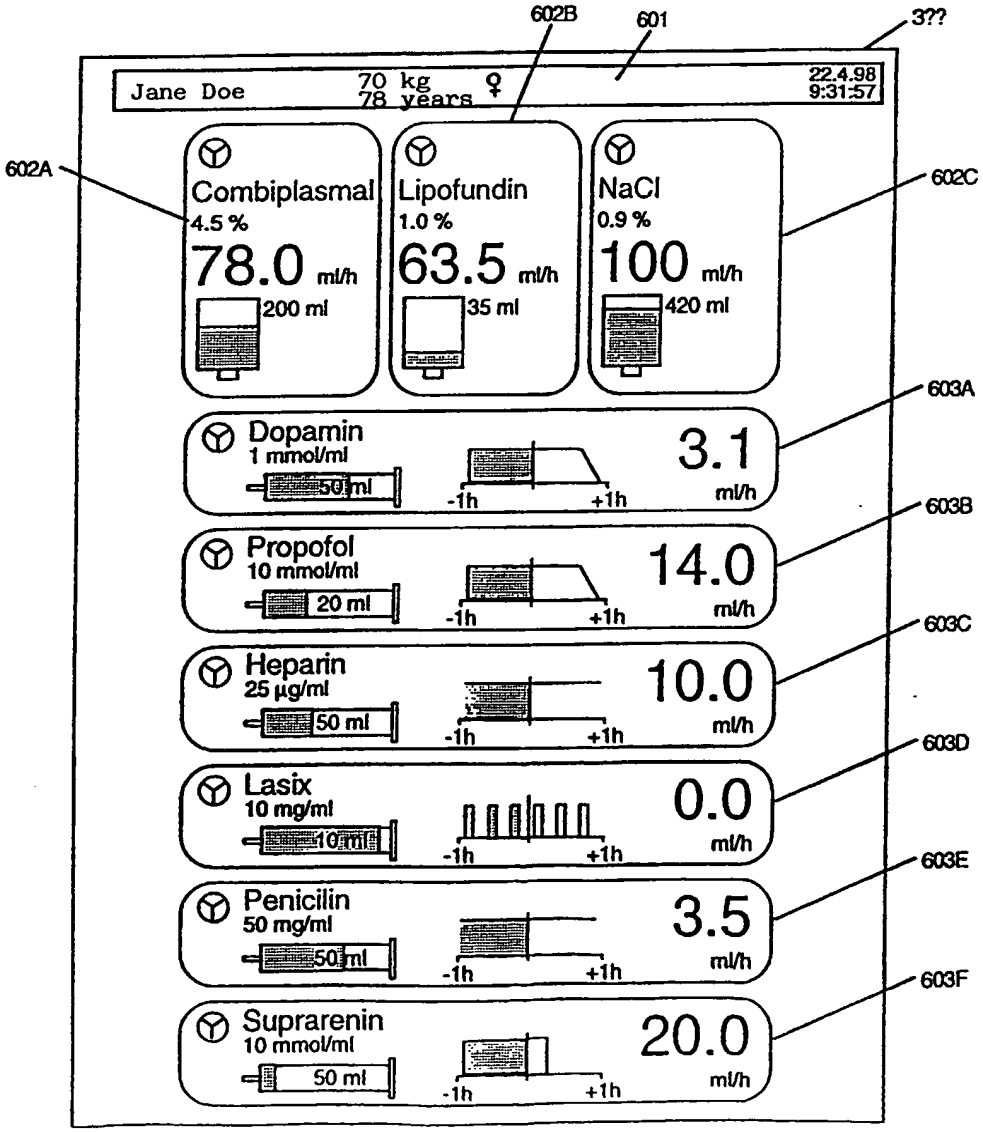
602B
601
3??
Jane Doe
70 kg
78 years
22.4.98
9:31:57
602A
Combiplasmal
4.5 %
78.0 ml/h
200 ml
Lipofundin
1.0 %
63.5 ml/h
35 ml
NaCl
0.9 %
100 ml/h
420 ml
602C
603A
Dopamin
1 mmol/ml
50 ml
3.1
ml/h
603B
Propofol
10 mmol/ml
20 ml
14.0
603C
Heparin
25 µg/ml
50 ml
10.0
603D
Lasix
10 mg/ml
10 ml
0.0
603E
Penicilin
50 mg/ml
50 ml
3.5
603F
Suprarenin
10 mmol/ml
50 ml
20.0
-1h
+1h

Fig. 6